Airborne sunphotometer (AATS-14) measurements in ARCTAS - first insights into their combined use with satellite observations to study Arctic aerosol radiative effects

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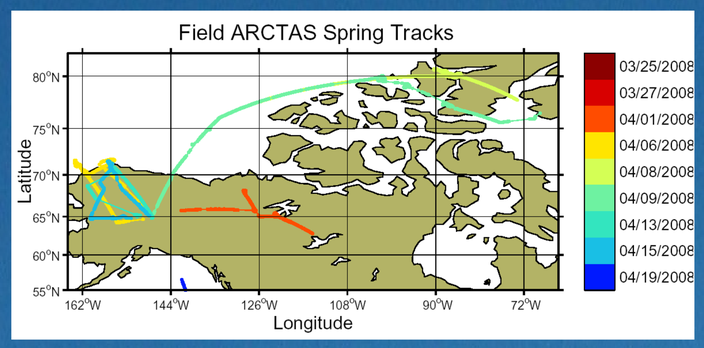
ARCTAS-spring



Abstract

During the 2008 Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) field deployment, the 14-channel NASA Ames Airborne Tracking Sunphotometer, AATS-14, operated successfully on all 24 (10 spring + 14 summer) NASA P-3B flights. AATS-14 collected science data on 20 of those flights, the exceptions being two transit, one engineering check flight and one science flight when environmental conditions (low T or persistent cloud cover) were unfavorable for AATS data collection.

AATS-14 science objectives for ARCTAS included integrated analysis of the horizontal and vertical distribution of Arctic Haze aerosols and the emissions from boreal forest fires, the combination of AATS-derived AOD measurements with solar irradiance measurements on the P-3B to determine aerosol direct radiative effects, and the use and validation of aerosol observations from MODIS, MISR, OMI, POLDER and CALIPSO in conjunction with AATS measurements to address ARCTAS science objectives.

A preliminary analysis shows abundant opportunities to address these science objectives, with concurrent AATS and satellite observations available for almost every science flight (see table). Here we present a preliminary summary of AATS observations from the spring and summer phase, comparisons of AATS AOD with in situ measurements on the P-3B (HiGEAR) and ground-based AERONET AOD measurements, and finally AATS, OMI, and MODIS AOD retrievals from measurements acquired during select summer-phase flights.

Preliminary Findings

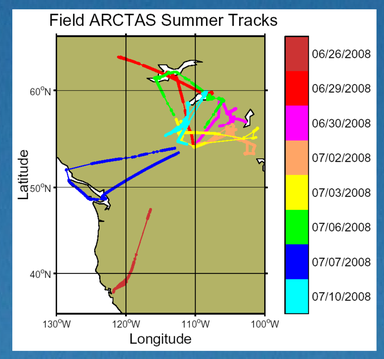
(1) In a preliminary analysis of 35 vertical profiles, AATS-14 measurements of layer AOD agree with AOD calculated from HiGEAR in situ observations to within 0.02±0.1*AOD.

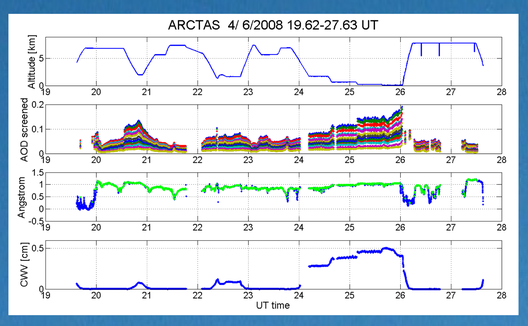
(2) Measurements of AOD from AATS-14 and AERONET agree well with AOD calculated from HiGEAR in situ observations in three cases studied in detail.

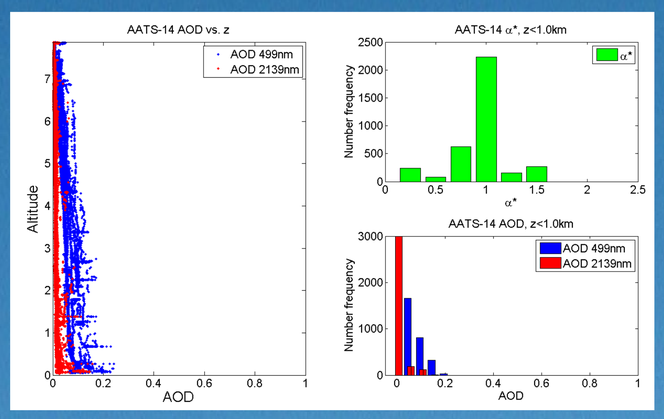
(3) An initial survey of the AATS data set indicates a Iconsiderable number of possible case studies for the “gradient method” of deriving aerosol direct radiative forcing efficiencies and a small number of possible cases for studying aerosol flux divergence.

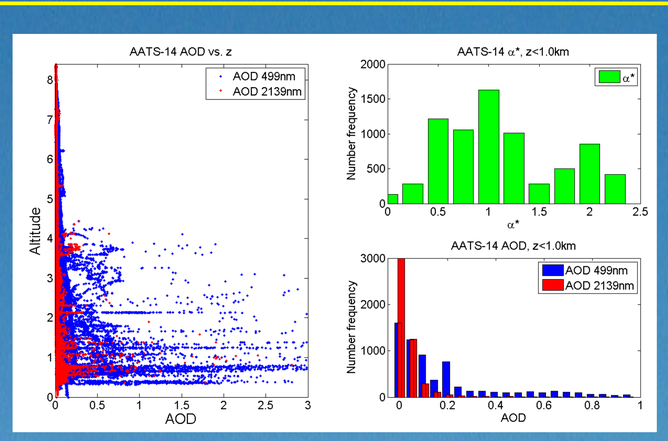
(4) Preliminary analysis of measurements acquired on June 30, 2008 during indicate that the AATS, OMI, and MODIS AOD retrievals appear to paint a consistent picture through the smoke plume, despite differences in the retrieved OMI aerosol models and in retrieved AODs outside the smoke. A coincident CALIPSO extinction profile in the smoke plume exists.

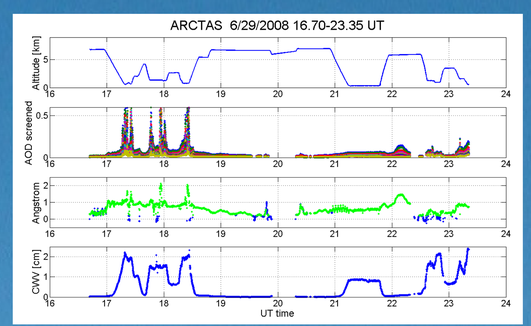
ARCTAS (Summer 2008): 3 AATS/OMI Coincidences

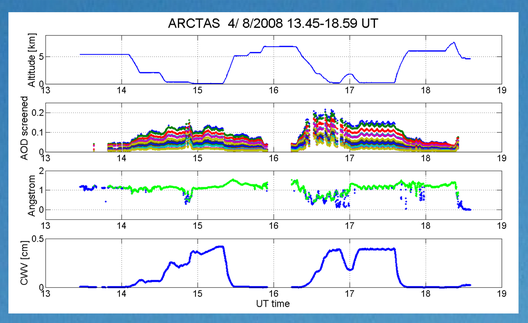


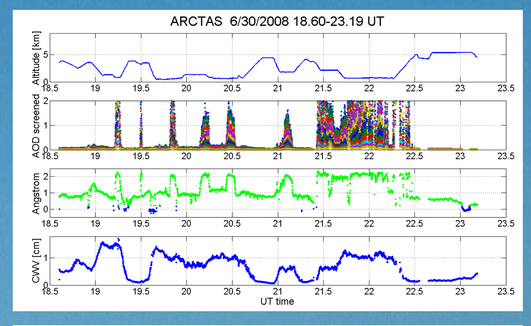


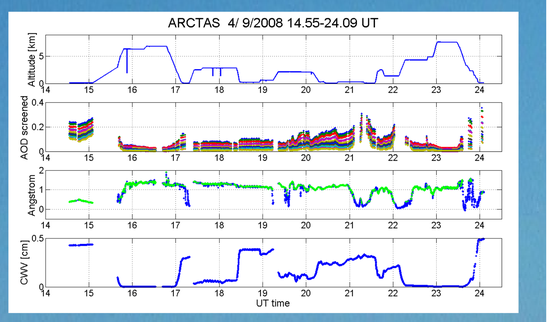




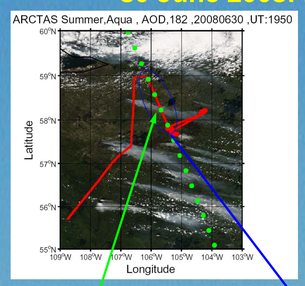


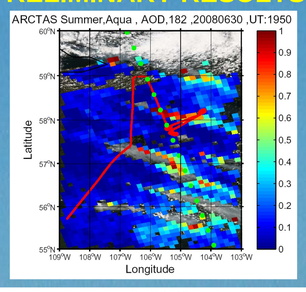


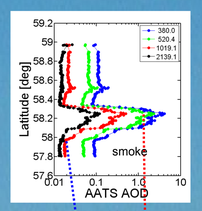




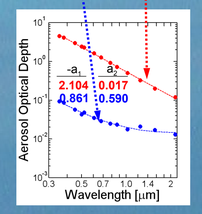
30 June 2008: PRELIMINARY RESULTS

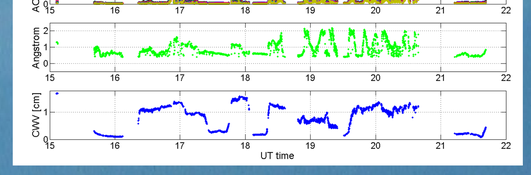


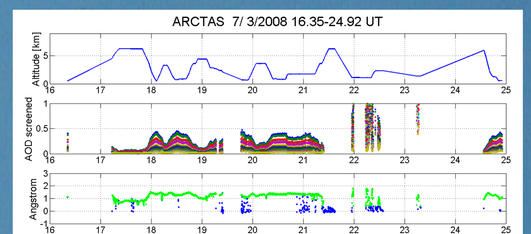


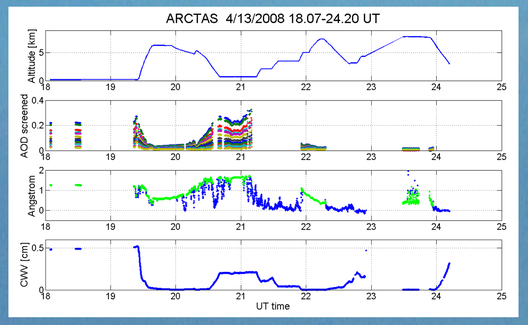


log AOD = a_0 + a_1*log λ + a_2*log²λ



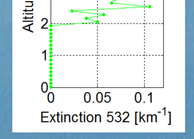


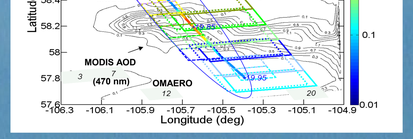




ARCTAS satellite OP info

Date	Flight #	Flight Locale	AATS data times (UT)	Satellite	OP time	Satellite AOD	AATS-14 (+-1 hour of sat. OP time) min(alt)	max(alt)	min AOD 519 nm	max AOD 519 nm
03/25/08	1	Test flight 1, WFF	16.7 - 17.67	Aqua	1720	MODIS	0.14	1.93	0.079	0.1895
03/27/08	2	Test flight 2, WFF	16.60 - 18.14	Aqua	1710	MODIS	0.714	7.499	0.0065	0.2377
03/31/08	3	Transit WFF -> Yellowknife	Transit							
04/01/08	4	Transit	16.52 - 22.25	Terra	1900		5.111	7.045	0.0162	0.1366
		Yellowknife -> Fairbanks		Aqua	1915		0.468	7.045	0.0162	0.1366
04/06/08	5	Local, FAI->FAI	19.62 - 27.64	Terra	2055		1.979	7.446	0.0215	0.139
				Aqua	2115		1.979	7.446	0.0217	0.0952
04/08/08	6	FAI->Thule	13.27 - 18.59	Terra	1545		0.052	6.9	0.0253	0.2049
				Terra	1725		0.16	7.683	0.0231	0.2405
				Aqua	1430		0.052	5.439	0.0277	0.1516
04/09/08	7	Thule->FAI	14.55 - 24.09	Terra	1450		0.08	6.382	0.0317	0.2122
				Terra	1630		0.064	6.89	0.0202	0.3122
				Terra	1805		0.064	2.858	0.0405	0.3122
				Terra	1950		0.057	2.137	0.0411	0.1808
				Aqua	1510		0.08	6.382	0.0269	0.2122
				Aqua	1515		0.08	6.382	0.0259	0.2122
				Aqua	1830		0.115	2.858	0.0405	0.1304
				Aqua	2005		0.057	2.137	0.0411	0.1808
04/13/08	8	Local, FAI->FAI	18.07 - 24.20	Terra	2100		0.655	5.798	0.0239	0.9439
				Terra	2105		0.655	5.875	0.0239	0.9439
				Aqua	1945		0.156	6.33	0.0203	0.5263
				Aqua	2120		0.655	7.448	0.0132	0.9439
04/15/08	9	Local, FAI->FAI	19.45 - 26.71	Terra	2050		2.661	7.328	0.0177	0.1487
				Terra	2230		0.164	7.328	0.0173	0.8461
				Aqua	1930		2.661	6.815	0.0142	0.1487
				Aqua	2105		2.673	7.328	0.0173	0.1172
				Aqua	2110		2.673	7.328	0.0173	0.0966
				Aqua	2245		0.164	7.328	0.0173	0.8461
4/19/2008	10	Transit, FAI -> Ames	17.84 - 25.40	Terra	2030	MODIS	0.044	7.405	0.0125	0.3761
				Aqua	2215	MODIS	1.011	6.002	0.0708	0.2794
6/24/2008	12	CARB Flight Ames ->Ames	16.98 - 24.72	??						
6/26/2008	13	Transit Ames	14.67 - 20.41	Terra	1830	MODIS	0.92	7.36	0.01	0.43
				Aqua	2010	MODIS	5.80	7.35	0.01	0.68
6/26/2008	14	Transit Edmonton ->Cold Lake	Transit							
6/28/2008	15	Local, Cold Lake	Test							
6/29/2008	16	Local, Cold Lake	16.70 - 23.35	Terra	1855	MODIS & MISR	0.75	6.76	0.01	3.82
				Aqua	2045	MODIS	0.24	6.98	0.01	0.49
6/30/2008	17	Local, Cold Lake	18.60 - 23.19	Terra	1800	MODIS	2.50	3.89	0.03	0.26
				Aqua	1950	MODIS & OMI	0.41	4.44	0.02	6.18
7/2/2008	18	Local, Cold Lake	15.10 - 21.69	Terra	1750	MODIS	0.34	3.25	0.03	2.00
				Aqua	1935	MODIS	0.67	3.52	0.04	5.27
7/3/2008	19	Local, Cold Lake	16.35 - 24.92	Terra	1830	MODIS & MISR	0.51	6.26	0.03	6.09
				Aqua	2020	MODIS	0.62	3.63	0.09	6.09
7/6/2008	20	Local, Cold Lake	17.74 - 24.03	Terra	1900	MODIS & MISR	0.20	6.15	0.01	0.08
				Aqua	1915	MODIS	0.00	6.15	0.01	0.14
				Aqua	2050		0.00	2.69	0.03	3.52
7/7/2008	21	Local, Cold Lake	18.68 - 25.62	Terra	1810	MODIS	6.14	6.21	0.01	0.76
				Terra	1945	MODIS	5.07	7.47	0.01	0.76
				Aqua	2130-	MODIS	0.05	7.49	0.03	0.73
7/9/2008	22	Local, Cold Lake	16.30 - 23.98		2135					
7/10/2008	23	Local, Cold Lake	17.47 - 22.92	Terra	1835-1840	MODIS & MISR	0.90	5.49	0.01	0.11
				Aqua	2025	MODIS	0.51	3.72	0.02	5.62
7/12/2008	24	Transit, Cold L. ->Wallops	14.01 - 16.00							

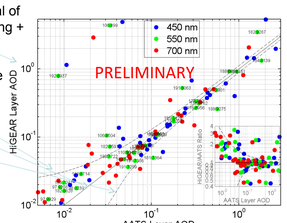


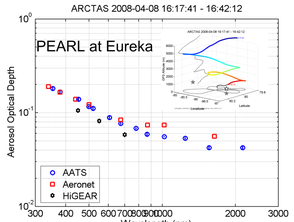


HiGEAR layer AOD was typically within 10% + 0.02 of AATS AOD for the 35 spiral vertical profiles with altitude change > 1 km

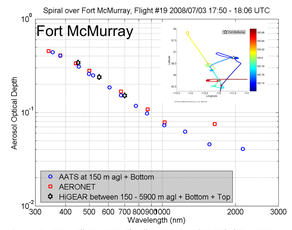
vertical integral of in-situ scattering + absorption coefficients, adjusted to the ambient RH

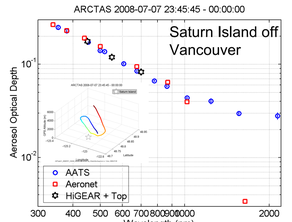
+10% + 0.02
1:1 agreement
-10% - 0.02





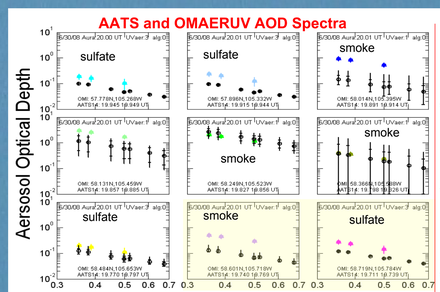
AATS and AERONET AODs agreed within 0 (excellent!) – 0.02 (good) during 3 fly-over events, at all wavelengths but 1.6 um.



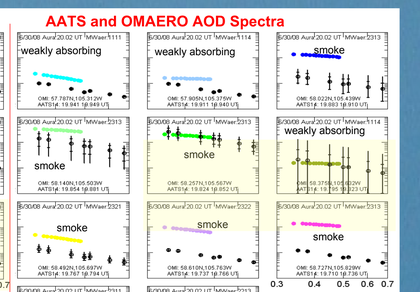


AERONET PIs: Brent Holben, Norm O'Neill, Bruce McArthur and Alain Royer

AATS and OMAERUV AOD Spectra



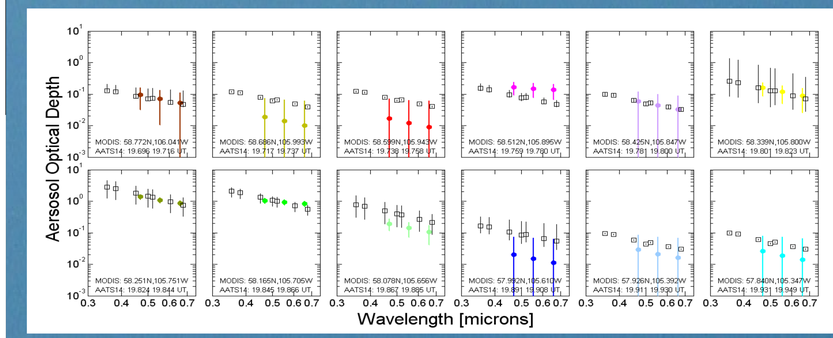
AATS and OMAERO AOD Spectra



AATS did not measure large AODS along P-3B track across the western end of dark blue OMI grid cell, but MODIS AOD on the eastern end is elevated, so larger OMI AODs seem consistent.

Highlighted cells probably cloud-contaminated.

Note: cloud-clearing turned off for OMAERO retrievals.



MODIS AOD retrievals are plotted with color-coded solid circles; vertical bars give the expected uncertainty for an over-land retrieval. Black squares show the AATS AOD means for all cloud-free measurements acquired along the segment of the aircraft track that intersects the particular MODIS grid cell; vertical bars delineate the range of AODs measured in the cell. AATS measurement uncertainties are not shown, as they are smaller than the square symbols.